SECTION 1

INTRODUCTION

1.1 Benthic invertebrates comprise a heterogenous assemblage of animal groups (taxa) that inhabit the sediment or live on or in other bottom substrates in the aquatic environment. They vary in size from forms small and difficult to see without magnification to other individuals large enough to see without difficulty.

1.2 The benthic invertebrates that are large enough to be seen by the unaided eye and which can be retained by a U.S. Standard No. 30 sieve (28 meshes per inch, 0.595 mm openings) and live at least part of their life cycles within or upon available substrates in a body of water or water transport system are defined as **macroinvertebrates**. If a more representative sample of the benthos such as chironomids and other small forms (e.g., naidid and tubificid oligochaetes or aquatic worms) is desired, a U.S. Standard No. 60 sieve (60 meshes per inch, 0.250 mm openings) may be used.

1.2.1 Benthos (n.), Benthic (adj.)--the community of organisms living in or on the bottom or other substrate in an aquatic environment.

1.2.2 Benthic invertebrate--an invertebrate of the benthos.

1.2.3 Habitat--the place where an organism lives; for example mud, gravel, rocks, shoreline, vegetation, twigs, leaf packs, riffle/run, pool, etc.

1.2.4 Microhabitat--a smaller and more restricted area in a habitat; the immediate environment of the organism.

1.3 The standard opening for estuarine and marine benthic animals is also U.S. Standard No. 30 sieve (28 meshes per inch, 0.595 mm openings), and new benthic programs should use the No. 30 sieve for collecting these animals. To accommodate some historical data bases, a 1.0 mm screen, U.S. Standard No. 18 sieve may be used.

1.4 Any available substrate may provide suitable habitat for benthos, including bottom sediments, submerged logs, debris, pilings, pipes, conduits, vascular aquatic plants, root masses, filamentous algae, etc. The major taxonomic groups of freshwater macroinvertebrates include the insects, annelids, mollusks, flatworms, and crustaceans. The major invertebrate groups in estuarine and marine water are the mollusks, annelids, crustaceans, roundworms, cnidarians (coelenterates), sponges, bryozoans, and echinoderms.

1.5 The macroinvertebrates are important members of food webs, and their well-being is reflected in the well-being of the higher forms such as fish. Many invertebrates, such as the marine and freshwater shellfish (clams and mussels), are important commercial and recreational species. Some, such as mosquitoes, black flies, biting midges, leeches, Asiatic clams, and zebra mussels, are of considerable public health significance or are considered pests. Many forms are important for digesting organic material and recycling nutrients.

1.6 Benthic macroinvertebrates are frequently used as environmental indicators of biological integrity because they are found in most aquatic habitats. They are of a size that makes them easily collected. They can be used to describe the water quality conditions or health of the ecosystem components and to identify causes of impaired conditions.

1.6.1 A community of macroinvertebrates in an aquatic lentic or lotic ecosystem is very sensitive to stress; and, thus, its characteristics serve as a useful tool for detecting environmental perturbation resulting from introduced point and non-point sources of pollution. Because of the limited mobility of these benthic organisms and because many species have life cycles of a year or more, their characteristics are a function of conditions during the recent past, including reactions to infrequently discharged pollutants that would be difficult to detect by periodic chemical sampling.

1.6.2 Macroinvertebrates show responses to a wide array of potential pollutants (agricultural, domestic, industrial, mining, etc.), including those with synergistic or antagonistic effects that adversely affect the physiological, biochemical, and reproductive functions of the species. The analysis of changes in the makeup of different aquatic communities is one way to detect water quality problems. Knowledge of changes in the community structure (abundance and composition) and function (see Section 1.7) of benthic macroinvertebrates helps to indicate water quality status and trends in the aquatic environment. Also the regular sampling of macroinvertebrates can be used to document both spatial and temporal changes in the biological integrity of surface waters. Different types of environmental stress will often produce different macroinvertebrate communities.

1.6.3 In addition, because of the phenomenon of "biological magnification" and relatively long-term retention of toxic substances by benthic organisms, toxic materials such as metals, pesticides, radioactive materials, which are only periodically discharged into the environment or which are present at undetectable levels in the water or sediment, may be detected by chemical analyses of selected components of the macroinvertebrate community.

1.7 Individuals or groups of macroinvertebrates can be separated into trophic levels, such as herbivores, omnivores, or carnivores and, in stream ecosystems, functional feeding relationships (Cummins, 1973, 1974, 1975; Cummins and Klug, 1979; Cummins et al., 1984; Cummins and Wilzbach, 1985). In a well-balanced system, all three types will likely be present. They include deposit and detritus feeders, collectors, shredders, grazers or scrapers, parasites, scavengers, and predators.

1.8 In most biomonitoring studies, identification at, or near the species level will be required to determine water quality conditions (Resh and Unzicker, 1975). Tolerant species (Appendix A) will usually become dominant only in polluted waters.

1.9 In pollution-oriented studies of macroinvertebrate communities, there are basically three sampling approaches--qualitative, semi-quantitative, and quantitative--that may be utilized singly or in combination. These sampling approaches are used to link ecosystem endpoints to stresses (e.g., physical

habitat alterations, inert solids, eutrophication, organic enrichment, thermal disruptions, ambient toxic wastes, and cumulative impacts) measured by bioindicator methods and techniques. See Section 5, Sampling Methods and Section 7, Data Evaluation.

1.10 During studies of water quality accommodations should be made for stream size, geographic location, and seasonality (Lenat, 1983). Also, flow conditions are related to the relative impact due to point and nonpoint sources of pollution. High flow usually increases the impact of nonpoint sources, while it reduces the impact of point sources. In streams with low flow, the reverse is often true. In addition, the presence, distribution, and abundance of aquatic macroinvertebrates, especially aquatic insects, may be subject to wide seasonal variations (Hilsenhoff, 1988). Thus, when conducting comparative studies, the investigator must be careful to avoid the confounding effects of these seasonal changes. Seasonal variations are particularly important in freshwater habitats dominated by aquatic insects having several life stages, not all of which are aquatic.

1.11 The design of macroinvertebrate studies should be based upon study goals and data quality objectives (DQOs) (See Section 2, Quality Assurance and Quality Control). To supplement the material contained in this manual, a number of basic references should be reviewed or available to investigators of the macroinvertebrate communities, particularly to investigators engaged in aquatic water quality and pollution studies. These include Armitage (1978), Benke, Gillespie, and Van Arsdall (1984), Brinkhurst (1974), Cairns and Dickson (1973), Cummins (1966, 1973, 1974, 1975), Cummins and Klug (1979), Cummins et al. (1984), Cummins and Wilzbach (1985), Edmondson and Winberg (1971), Elliott (1977), Goodnight and Whitley (1960), Hart and Fuller (1974), Hellawell (1978, 1986), Hilsenhoff (1977), Howmiller and Scott (1977), Hynes (1960, 1970), Holme and McIntyre (1971), Hulings and Gray (1971), Lenat (1983), Lind (1974), Merritt and Cummins (1984), Mason (1981), Metcalfe (1989), Milbrink (1983), Meyer (1990), Neuswanger, Taylor, and Regnolds (1982), Pennak (1989), Posey (1990), Resh (1979), Resh and Rosenberg (1984), Resh and Unzicker (1975), Reynoldson et al. (1989), Ward and Stanford (1979), Warren (1971), Waters (1977), Welch (1948), Welch (1980), and Winner et al. (1975).

1.12 This manual was composed to assist biologists and managers in USEPA and other Federal, state, and private water monitoring organizations in the use of macroinvertebrates for evaluating the biological integrity of surface waters. The manual contains laboratory and field methods that will aid in the monitoring, detection, and bioassessment of surface waters and the effects of environmental stress on macroinvertebrate communities. It will also facilitate the expansion of our knowledge of the ecological requirements of macroinvertebrate species in fresh, estuarine, and marine habitats. The manual includes sections on quality assurance and quality control, safety and health, sampling site selection, sampling methods and techniques, sample processing, data evaluation, and a taxonomic bibliography, containing the current taxonomy used for identifying the macroinvertebrates of North America. Information on the pollution tolerance of selected species and examples of bench and data summary sheets are provided in the Appendices.

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